Research

EXECUTIVE SUMMARIES : BY RONALD ASKIN AND THOMAS O. BOUCHER

This month we highlight two IIE Transactions *articles focusing on industrial engineering applications in healthcare delivery. The first article uses a simulation-optimization approach to set a breast cancer screening policy for older women. The second article develops a solution method for assigning traveling rehabilitation therapists to patients. These articles will appear in the July 2014 issue of* IIE Transactions *(Volume 46, No. 7).*

Authors Jeremy Tejada (from left), Russell King, James Wilson and Julie Ivy examined breast cancer screening policies for women 65 and older.

Research by Bonnie Yankaskas (from left), Michael Kay and Matthew Ballan found that annual breast cancer screenings were optimal for older women.

Should all older women be screened for breast cancer?

Breast cancer affects one in eight women in the United States. A woman's chance of surviving the disease depends on early detection and treatment. Accepted detection procedures are screening mammograms and clinical breast exams. In the future, half of all new breast cancer diagnoses are expected to be in women aged 65 and older.

The U.S. Preventive Services Task Force recommends biennial screening for women between ages 50 and 74, while the American Cancer Society recommends annual screening for women ages 40 and older.

Identifying optimal breast cancer screening policies for U.S. women ages 65 and older is investigated in "Combined DES/SD Model of Breast Cancer Screening for Older Women, II: Screening-and-Treatment Simulation" by Jeremy Tejada from SIMCON Solutions LLC; Matthew Ballan and professors Julie Ivy, Russell King, James Wilson and Michael Kay from North Carolina State University; professor Bonnie Yankaskas from the University of North Carolina at Chapel Hill; and professor Kathleen Diehl from the University of Michigan. A two-phase simulation framework is developed to measure the effectiveness of breast cancer screening policies for women ages 65 and older, including one-size-fits-all policies and personalized policies based on individual risk factors.

The first phase encompasses a natural history simulation of the incidence and progression of untreated breast cancer for individuals in the simulated population. The second phase screening-and-treatment simulation uses the individual health histories generated in the first phase to estimate the benefits, harms and costs of different policies for screening each woman in the simulated population and treating selected individuals with detected breast cancer.

Extensive simulation-optimization experiments are used to identify screening policies that over the period 2012 to 2020 will minimize breast cancer deaths or maximize quality-adjusted life-years saved. The resulting top five policies are compared with the U.S. Preventive Services Task Force and American Cancer Society policies. From both practical and statistical perspectives, annual screening for all women between ages 65 and 80 is found to be a superior policy by achieving a meaningful compromise between the cost-effectiveness of the U.S. Preventive Services Task Force policy and the effectiveness in averting deaths embodied in the American Cancer Society's policy. Equally significant is that the screening-and-treatment simulation can be used to evaluate almost any breast cancer screening policy.

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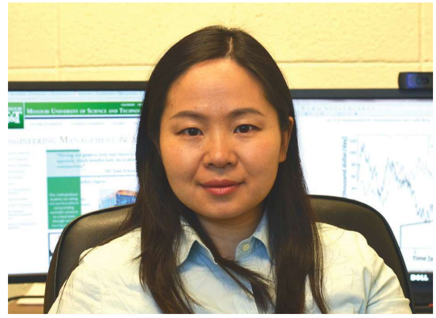
Jonathan Bard and his co-authors developed an algorithm to optimize home healthcare scheduling.



Ruwen Qin (left) and Ahmed Al sharif studied how adding flexibility to long-term contracts alleviates the concerns of participants.

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Taking the guesswork out of home healthcare scheduling

Imagine that you are a planner for a rehabilitation agency who must construct weekly schedules for your therapists. Each therapist has a different level of skill and experience, a different pay rate and different availability each week. Shift lengths, start times, and home bases also vary by individual.

Confounding your problem is the patient population, which is scattered around a wide geographic area, has different needs and hence different treatment requirements. If this wasn't confusing enough, labor laws and contractual agreements require lunch breaks for shifts longer than six hours and overtime after 40 hours are accumulated in a week. The tools you have for scheduling are little more than an Excel spreadsheet and a whiteboard and seem totally inadequate as the agency's business grows. Costs are rising much faster than revenues and your boss wants to know what you plan to do about it.

The answer comes from the work of Jonathan Bard at The University of Texas at Austin, Yufen Shao at ExxonMobil, Xiangtong Qi at Hong Kong University of Science and Technology, and Ahmad Jarrah at The George Washington University. In their paper, "The Traveling Therapist Scheduling Problem," they offer a new model for constructing weekly schedules for therapists who treat patients with fixed appointment times at various healthcare facilities throughout a large metropolitan region. The objective is to satisfy the demand for service over a five-day planning horizon at minimum cost subject to a variety of constraints related to time windows, overtime rules and breaks.

To gain an understanding of the computational issues, the complexity of various relaxations is examined and characterized. The results indicate that even simple versions of the problem are extremely difficult. The model the authors developed takes the form of a large-scale mixed-integer program, but it was not solvable with the commercial solver CPLEX for instances of realistic size.

Subsequently, a branch-and-price-and-cut algorithm was implemented and proved capable of finding near-optimal solutions for small instances. High-quality solutions were ultimately found in minutes with a rolling horizon algorithm, even for large instances with 20 therapists and 650 weekly visits. The company is now testing the approach in one of its Midwestern offices.

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The most recent issue of The Engineering Economist *(Volume 59, Number 1) contains four articles, two of which are highlighted here. The first article introduces the use of price adjustment flexibility in long-term contracts as real options. The second article explores the application of empirical tests of stochastic dominance in project analysis using spreadsheets.*

Adding flexibility to long-term contracts

Many industries commonly use long-term contracts for securing stable incomes, services and supplies. However, the intrinsic value of a contract may deviate dramatically from its original price if the spot market of the contracted asset or service is highly volatile. Therefore, market participants have serious concerns about being locked into deeply unfair contracts or the possibility that their counterparties would break such contracts.

For example, the Clarksea index of freight rates reached a peak of 47,567 at the end of 2007; however, in April 2009 the index dropped almost 85 percent to a low of 8,025. The flexibility in adjusting the original contract price to the most recent price after a tremendous change in the market helps maintain a fair long-term relationship between contract parties.

As an attempt to renovate long-term contracts, in the article "Valuation of Lease

Contracts with a Price Adjustment Option: An Application to the Maritime Transport Industry," Ahmed Al sharif and Ruwen Qin of Missouri University of Science and Technology model the price adjustment flexibility for long-term contracts as a real option, calibrate the monetary compensation for the flexibility's provider, and build a straightforward tool to maximize the owner's benefit of flexibility. The flexibility can be customized to meet the different budgets and requirements of the participants. The authors illustrate the implementation of the proposed approach by embedding the price adjustment flexibility in time charter contracts, a representative type of long-term contracts in the maritime transport industry.

The price adjustment flexibility defines a price range within which the original contract is fair to both contract parties. Yet renegotiation should be allowed if the market price goes outside the defined range. The flexibility mitigates participants' concerns because it overcomes the major drawback of long-term contracts. The proposed price adjustment flexibility makes long-term contracts an alternate tool for hedging price risks, particularly for participants reluctant to use financial derivatives. By modeling the single-sided flexibility, this paper has built a foundation for developing the double-sided flexibility, a more practical form for practitioners.

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Making stochastic dominance inferences in a spreadsheet platform

Empirical inadequacies of direct application of stochastic dominance (SD) rules and its variants have led to the development of statistical tests for making dominance inferences. Yet the algorithms for their implementation are not readily available to the analyst who uses spreadsheets for comparing alternative risky capital investments.

So in "Empirical Tests of Stochastic Dominance in Capital Investment Planning: A Spreadsheet Framework," Emmanuel Donkor considers the practical problem of inferring dominance relationships by using empirical tests of stochastic dominance.

First, the author summarizes the computational framework for conducting empirical tests of first-order stochastic dominance and second-order stochastic dominance and formulates this framework in a capital investment planning context. He then develops a spreadsheet computational platform for implementing empirical tests of SD and demonstrates how such tests can be implemented.

In this regard, the author uses numerical examples that consider cases for both continuous and discrete probability distributions. Although the study uses a simulation add-in to generate bootstrap samples and to compute the p-values required for making dominance inferences, the paper also provides an appendix and a companion supplemental spreadsheet file that walks readers through the mechanics of modeling empirical tests of SD without such add-ins.

Thus, analysts involved in comparing risky capital investments do not have to use visual inspection of cumulative density functions to make first- or second-order dominance inferences. Rather, they replicate the framework developed by the author to model and empirically test for these relationships if they wish to make empirically defensible decisions when comparing risky capital investments.

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Emmanuel Donkor researched stochastic dominance inferences with a view to helping analysts involved in comparing risky capital investments.

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About the journals

IIE Transactions is IIE's flagship research journal and is published monthly. It aims to foster exchange among researchers and practitioners in the industrial engineering community by publishing papers that are grounded in science and mathematics and motivated by engineering applications.

The Engineering Economist is a quarterly refereed journal devoted to issues of capital investment. Topics include economic decision analysis, capital investment analysis, research and development decisions, cost estimating and accounting, and public policy analysis.

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